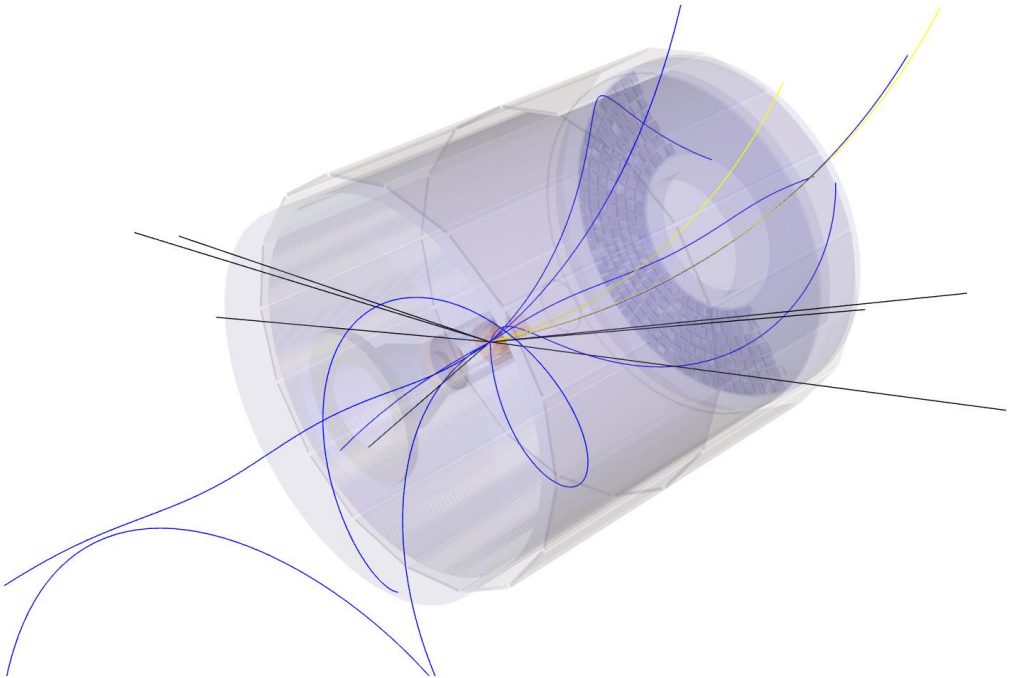
Introduction to Belle II Masterclass

2nd JENNIFER2 Summer School – july 27 2021

Connect to: /https://belle2.ijs.si/masterclass
Suggested browsers are Firefox and Chrome
All software is integrated in the web interface

You Tube introduction:
- Start: https://youtu.be/q6M2_dnp3pI
- Particle distribution: https://youtu.be/q6M2_dnp3pI
- J/psi to mumu: https://youtu.be/xUYmXoPfZOU
- J/psi to ee: https://youtu.be/3TGsHJ8j8pE
- B to J/psi K http://youtube.com/watch?v=e GErqzY3HM



General Notes

- you will work in small groups. The website will first prompt you asking to choose a nickname and to select a group number. Please indicate the same number as the zoom room in which you will be. You can always change it from the menu «Preferences».
- Each group will have a tutor/guide to whom you can ask questions and get help.
- The webpage provides a simplified event display which you can look at. There are a number or pre-loaded events which you can check, the particle list is printed together.
- From the «Help» menu you can access some video material about Belle II, including Virtual Reality videos.
- In principle the package has an advanced level to which you can switch from the «Settings» menu, but this level is under maintenance now, so we will not use it.
- The menu «My Worksheet» allows you to save your results, which will be then visible to the tutors. Please use it, so we will be able to compare different results for the final discussion.

Simple combination of reconstructed particles is possible through a graphical interface based on Blockly package.

Blocks

The exercises are any carried out by transferring blocks on the workspace and connecting them together. That represents parts of the data analysis code:

Inside “Blocks" we find:

A BLUE block that allows you to load events.

You can choose between 3 data sources:

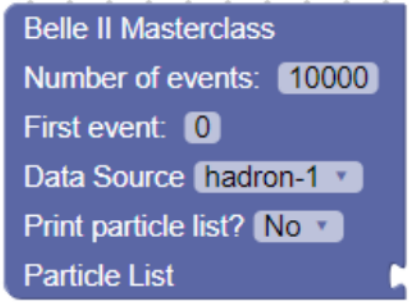
Belle II dataset which contains **7 Milion events**

Belle -1 Which contains 629000 events (Belle data)

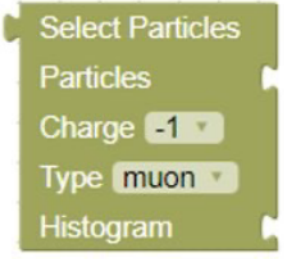
Belle -2 Which contains 5.6 Milion events (Belle data)

You can select the number of events to analyze

Note: processing of 7 Milion events takes up to 5 minutes.



A MUSTARD block that allows to select only certain particles (electrons, muons, kaons, protons, photons) and also allows to choose the charge of the particle (-1, 0, +1, any).

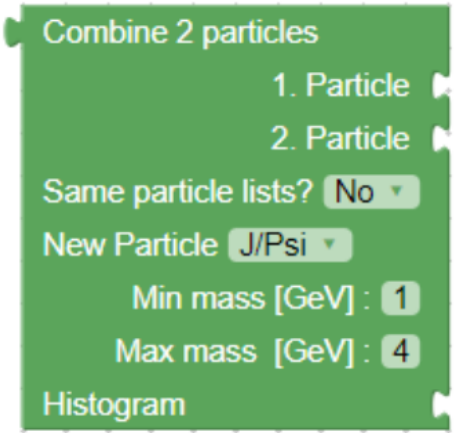


Blocks

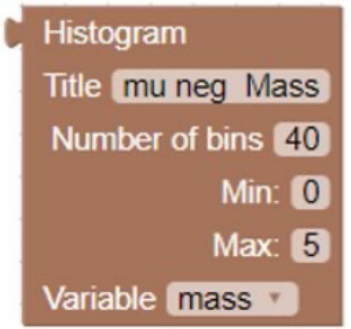
A GREEN block that allows you to combine two particles and to calculate their invariant mass

You can choose to combine different particles and avoid considering the same particle twice.

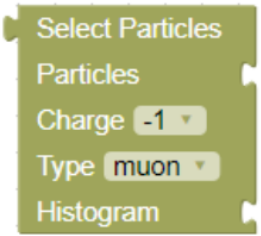
The minimum and maximum of the invariant mass can be specified for further analysis



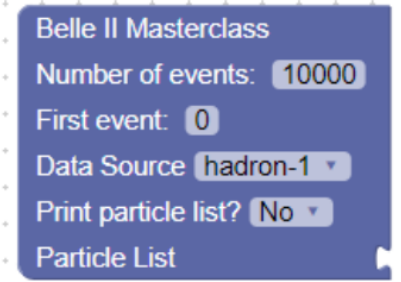
A BROWN block that allows you to produce histograms – distributions of selected variables, you can define a range and a variable to plot



Basic blocks

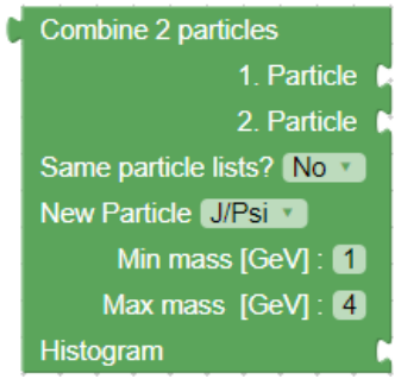


Select particle type for analysis and append histogram for plotting the properties

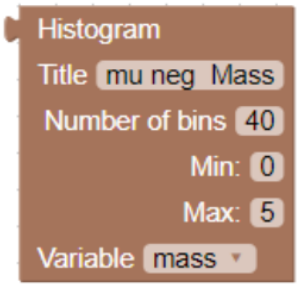


Define main analysis parameters

- ❑ Number of events to process
- ❑ First event to process
- ❑ Data Source
- ❑ Print particle list for first 100 events
- ❑ Particle list to process/ by default the list from the file is used



Make a combination of particles from two lists



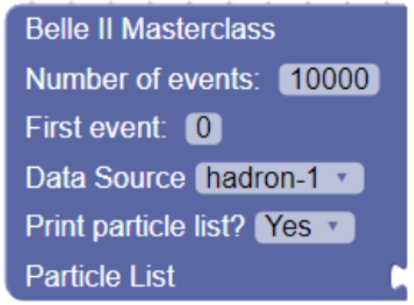
Plot a distribution

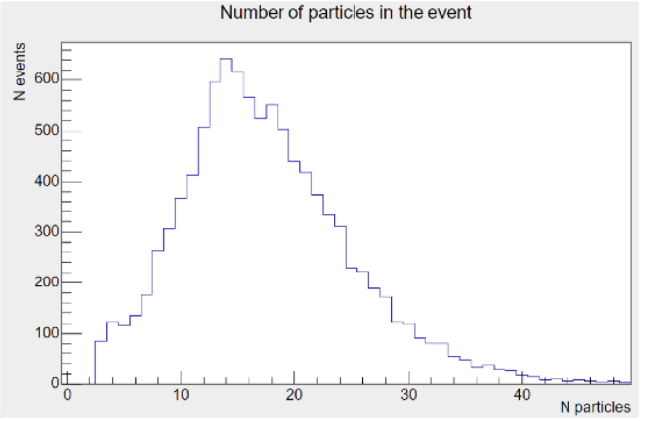
Define a range and a variable to plot

All parameters in the blocks can be varied

Particle list

- Without any connected blocks the particle list is listed if only a main block is included in the sketch





Primary particle list for Event 1

N	px(GeV/c)	py(GeV/c)	pz(GeV/c)	p(GeV/c)	Energy(GeV)	Charge	ID
1	-0.99205	0.255215	-0.298016	1.06682	1.06682	-1	electron
2	0.379417	0.416063	0.292391	0.634475	0.634475	-1	electron
3	0.448819	0.279332	0.857395	1.00727	1.01689	1	pion
4	-0.381274	0.317797	0.666425	0.830956	0.842596	-1	pion
5	-0.404262	0.0618774	0.419536	0.58589	0.602285	-1	pion
6	0.0363708	-0.337713	0.696636	0.775032	0.787499	1	pion
7	-0.125205	0.251112	0.201202	0.345276	0.372418	-1	pion
8	0.111522	0.10243	0.139017	0.205559	0.248464	1	pion
9	0.0599534	0.0198644	0.0726116	0.0962364	0.169532	-1	pion
10	-0.0335806	0.0421883	0.0666954	0.0857659	0.163816	1	pion
11	0.180846	-0.00941455	0.265317	0.321227	0.321227	0	photon
12	0.354789	0.0498766	0.227253	0.424272	0.424272	0	photon
13	0.393443	-0.310244	0.28901	0.578425	0.578425	0	photon
14	0.254512	-0.0893971	0.113315	0.29259	0.29259	0	photon
15	0.152624	-0.0325375	0.296991	0.335494	0.361627	0	pion
16	0.650451	-0.401558	0.403939	0.864582	0.875054	0	pion

Combine the blocks

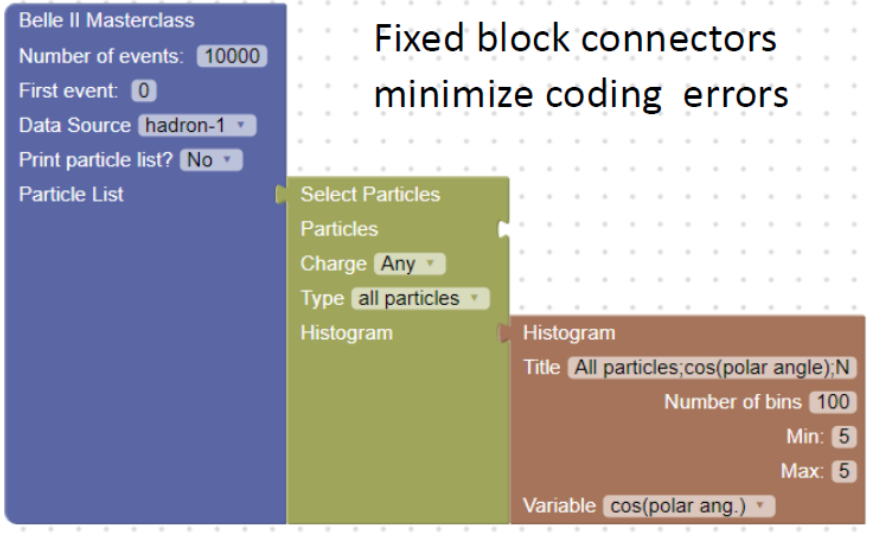
The particle lists for each event are stored in an ROOT tree.

By combining different blocks the event loop is generated. Inside the loop, new particle lists can be generated by combining the existing lists.

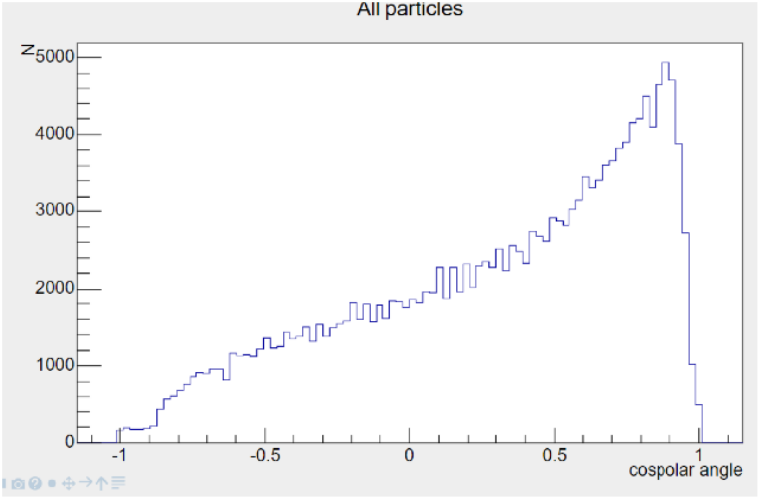
Distribution of different particle quantities can be plotted

Plot different variables :

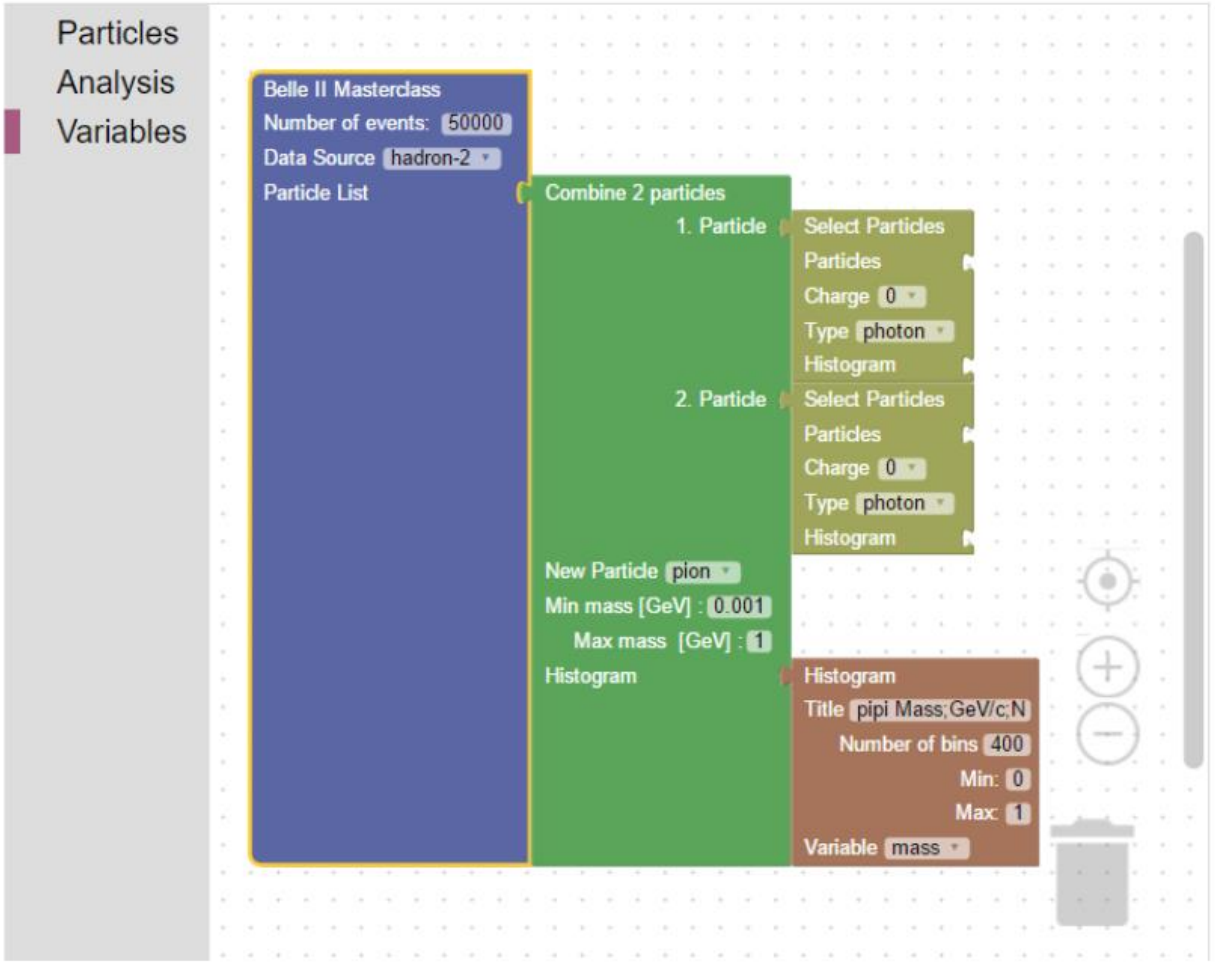
- ❑ mass,
- ❑ momentum,
- ❑ energy,
- ❑ charge,
- ❑ identity,
- ❑ px,py,pz,pT
- ❑ cos(theta),
- ❑ theta



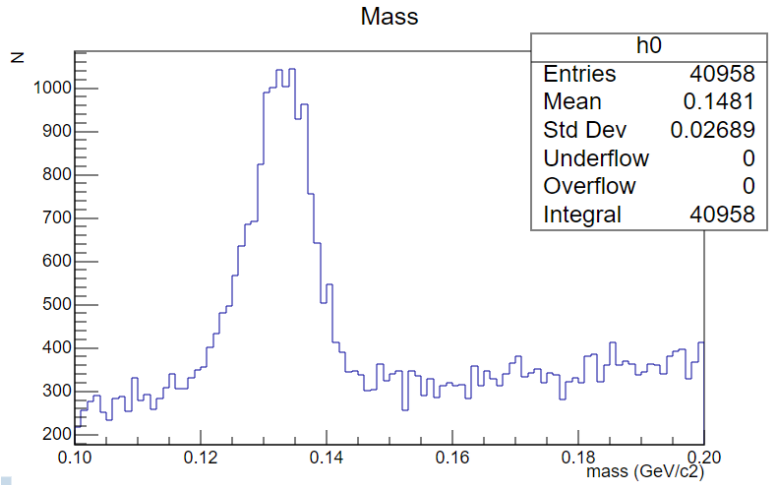
Fixed block connectors minimize coding errors



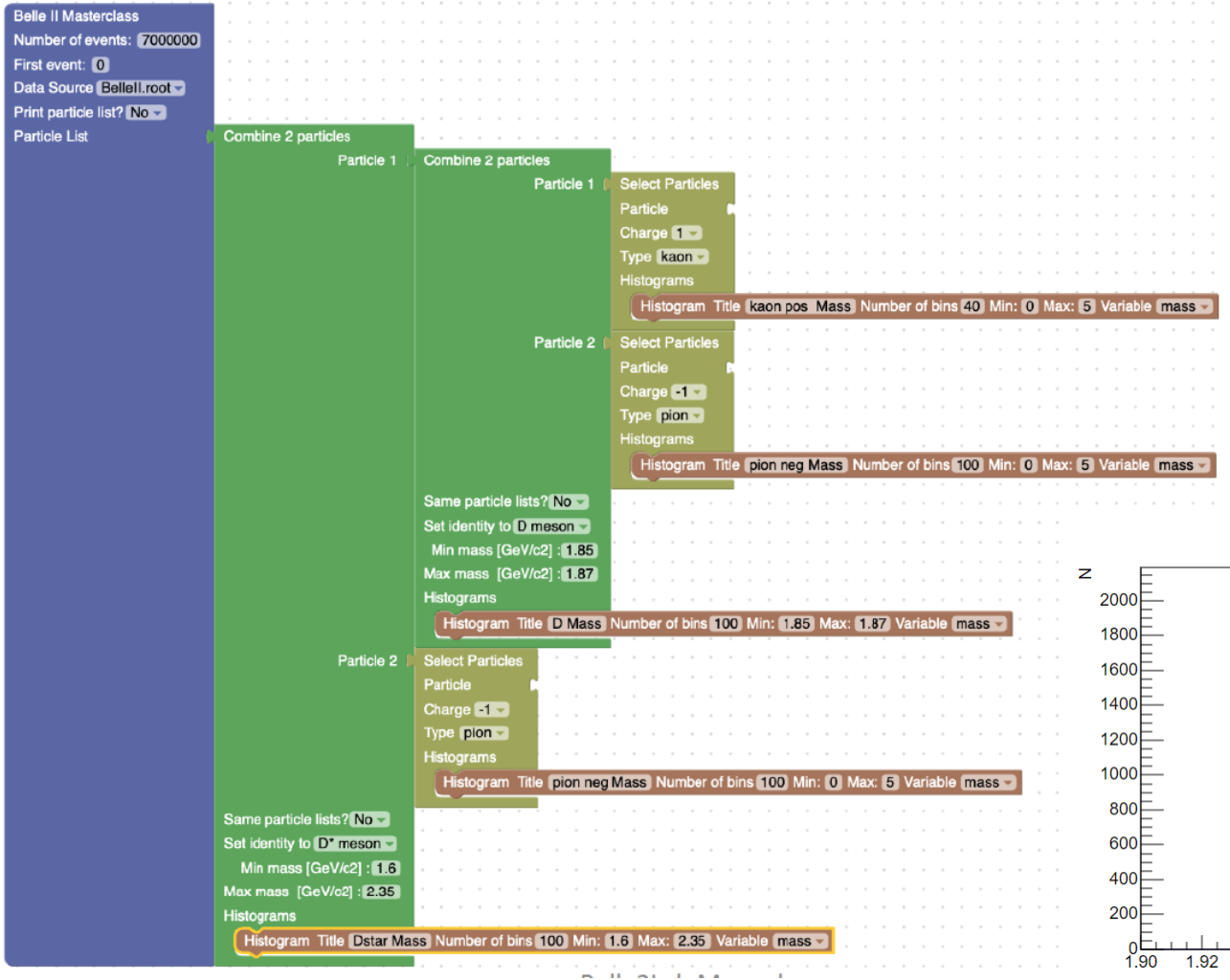
Decay to two particles



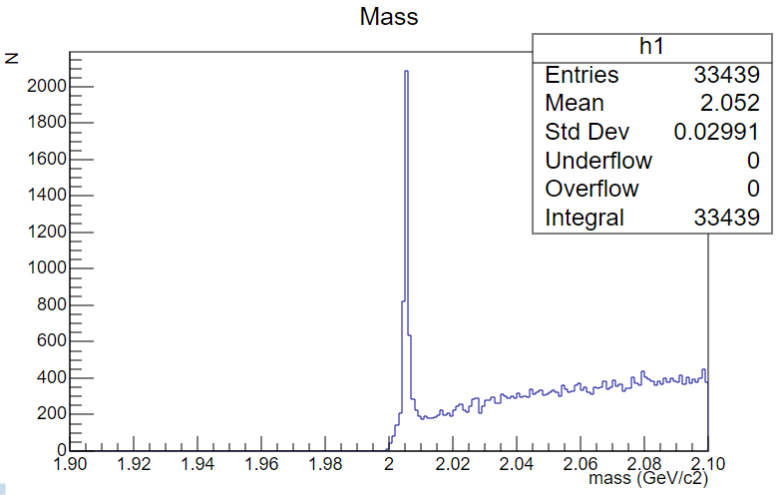
$\pi^0 \rightarrow \gamma\gamma$.



Combination of three particles

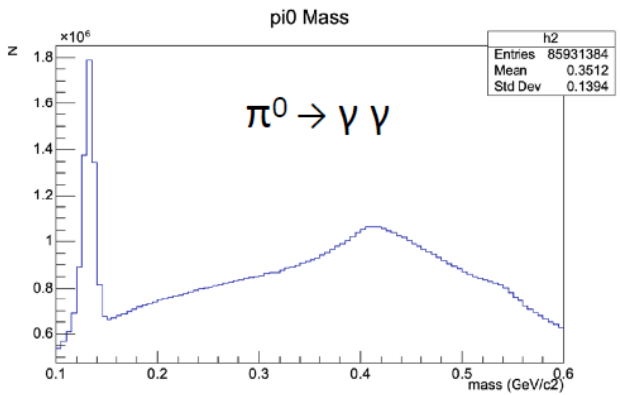


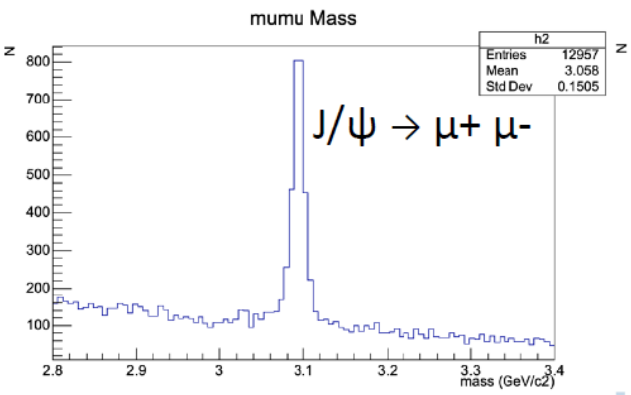
$D^* \rightarrow D^0 (\rightarrow K\pi)\, \pi.$

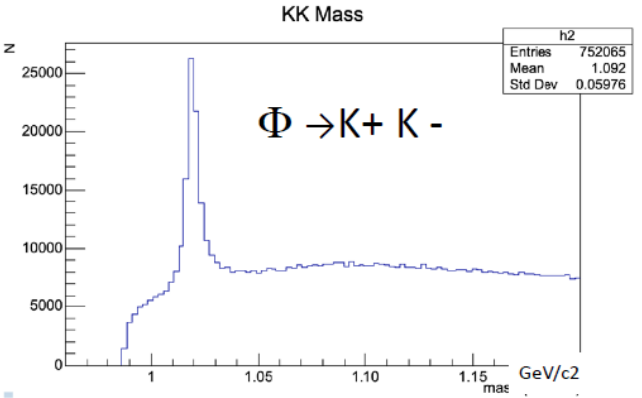


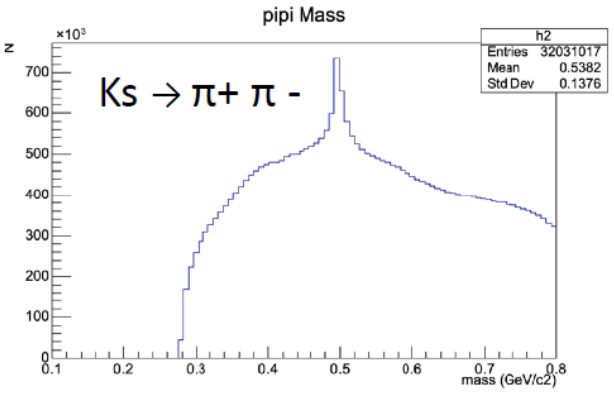
Different decays

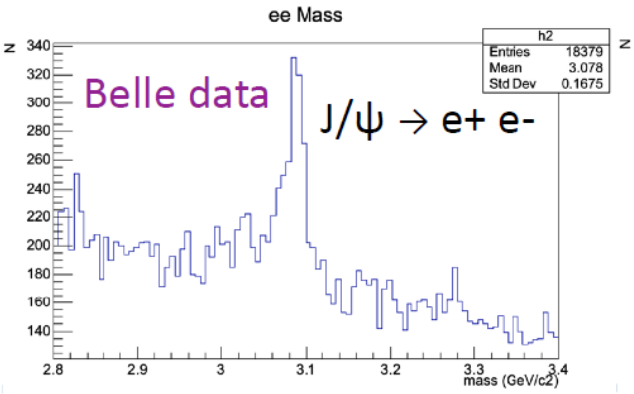
Invariant mass plots for different decays

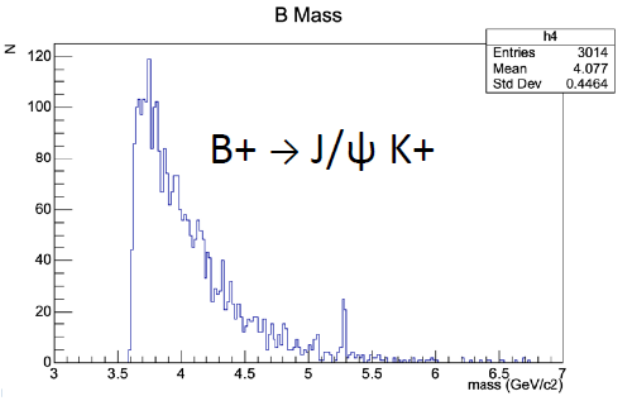












This plot are a reference for your results → they should not necessary be exactly like yours

Histograms and Fitting

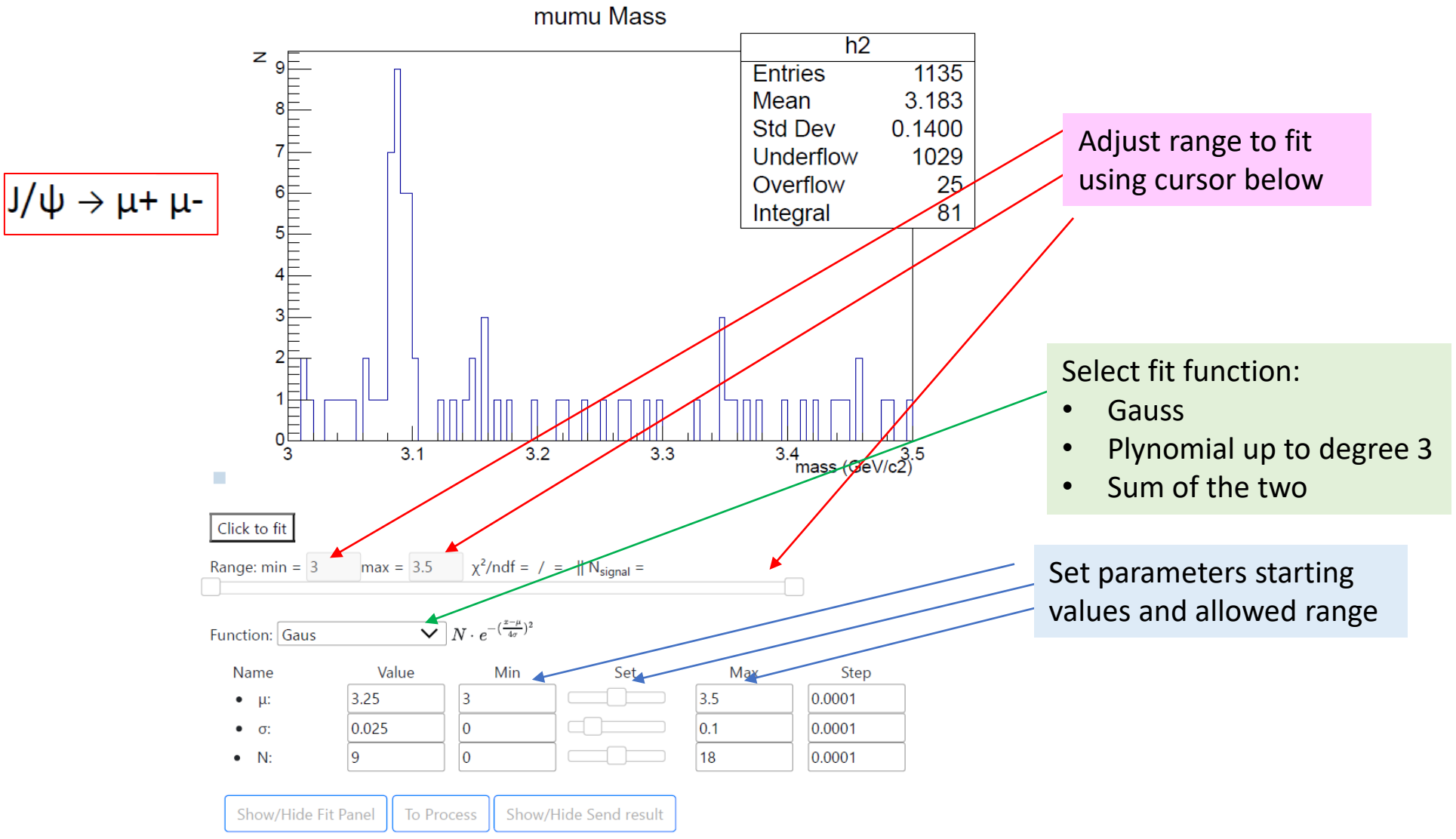
- **The exercise is organized in 9 different «Missions» which correspond to the reconstruction of decays of increasing complexity.**

- To «see» good signals it is important that you tune the selection on the particles in the blocks restricting them to the interesting region.

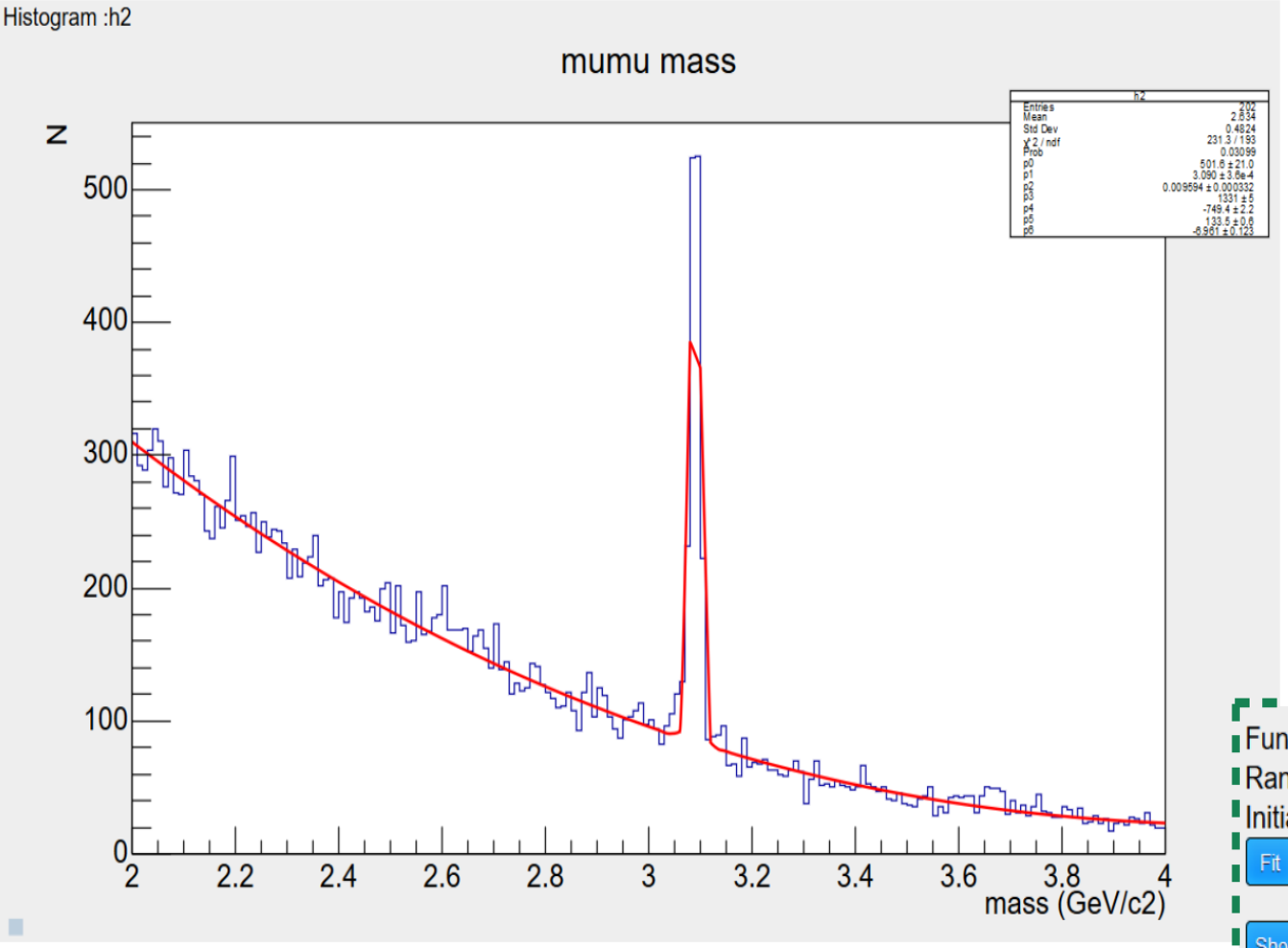
- Right clicking on all parts of the histograms they can be customized. Right-click on center of histogram allows you also to save it on your computer.

- At the bottom of each histogram you will be prompted a fit panel (which can be hided if necessary), where you can select a fitting function (Gaussian or polynomial or the sum of the two) and input fitting limits, starting values and limits for fit parameters.

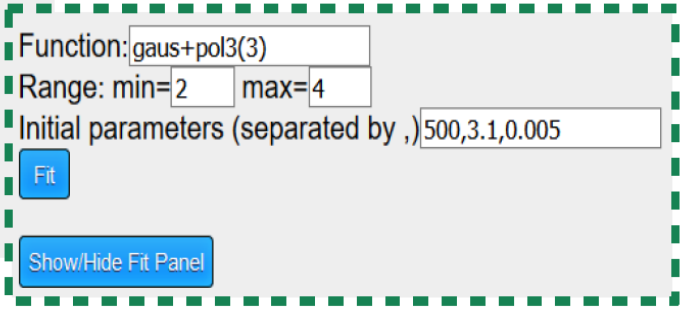
- The button Show/hide/send results opens a panel wher you can summarize the rusult of your fit and save it.

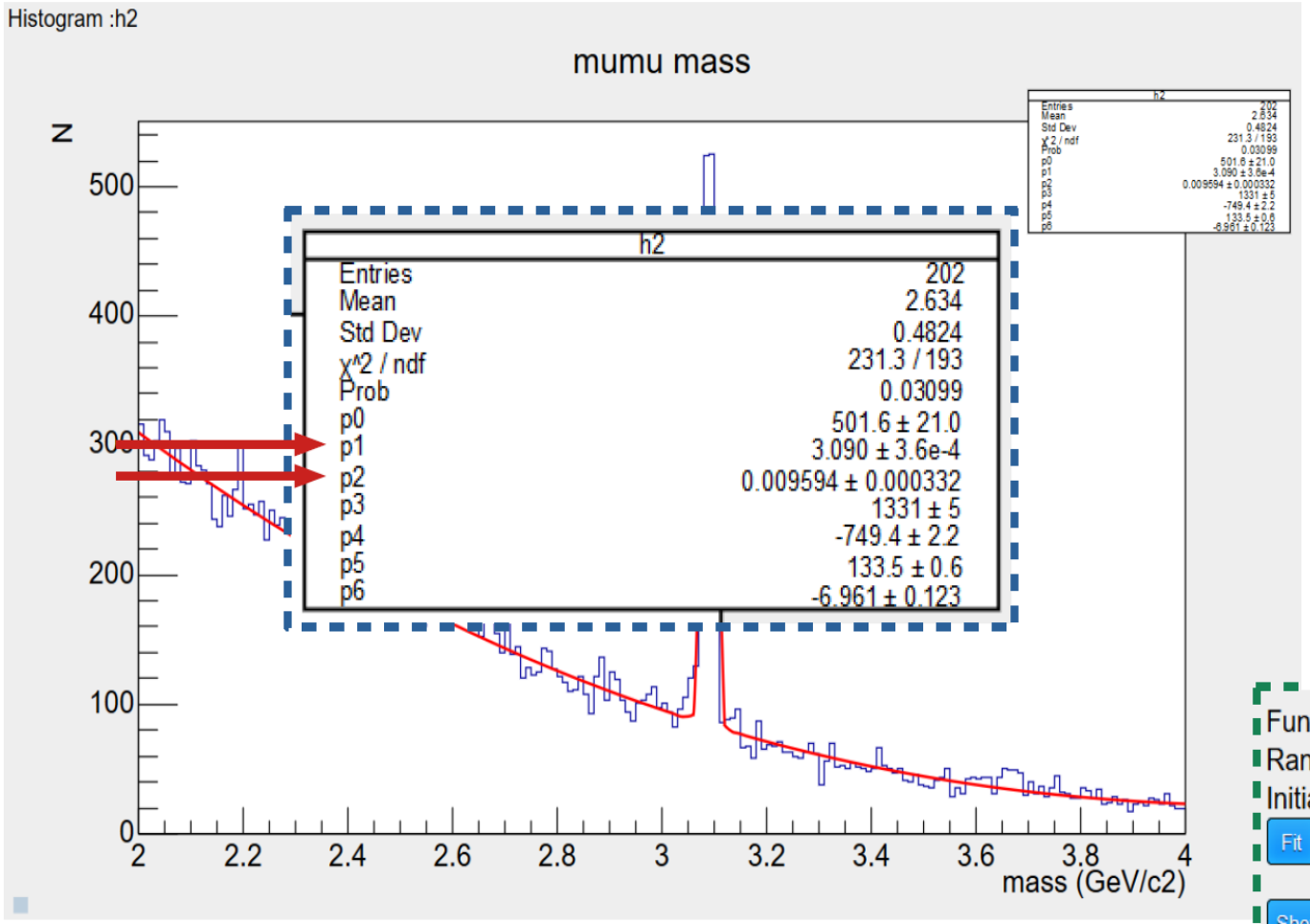

mumu Mass
h2
Entries 1135
Mean 3.183
Std Dev 0.1400
Underflow 1029
Overflow 25
Integral 81
N
mass (GeV/c2)
J/ψ → μ+ μ-
Adjust range to fit using cursor below
Select fit function:
• Gauss
• Plynomial up to degree 3
• Sum of the two
Set parameters starting values and allowed range
Click to fit
Range: min = 3 max = 3.5 χ²/ndf = / = N_signal =
Function: Gaus
Name Value Min Set Max Step
μ: 3.25 3 3.5 0.0001
σ: 0.025 0 0.1 0.0001
N: 9 0 18 0.0001
Show/Hide Fit Panel
To Process
Show/Hide Send result

Fitting signal + background

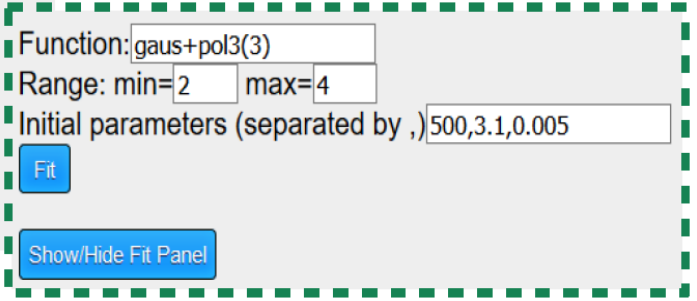


Adjust degree of polynomial
Try more combinations and parameters value/range





Check quality of the fit: χ^2/ndf and parameters errors: undetermined parameters are useless……..



HAVE FUN !!!